REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

AD-A232 698

2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
31 January 1991	Annual 15 Dec 89 - 14 Dec 90

4. TITLE AND SUBTITLE
Strategies to Sustain and Enhance Performance in Stressful Environments.

5. FUNDING NUMBERS
Project 2312
Task A2
AFOSR-90-0125
PE- 61102F

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
AFOSR-TR- 91 0170

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Office of Scientific Research /NL
Building 410
Bolling AFB, DC 02332-6448

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

DTIC FILE COPY

11. SUPPLEMENTARY NOTES
Annual Technical Report for 15 December 1989 to 14 December 1990

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

DTIC ELECTE MAR 14 1991 S D

13. ABSTRACT (Maximum 200 words)
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14. SUBJECT TERMS
L-Tyrosine, Melatonin, Stress, Performance, Pilots, Light, Sleep Deprivation, Human

15. NUMBER OF PAGES
6

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
U	U	U	U

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18

Report AFOSR-90-0125

Strategies to Sustain and Enhance Performance in Stressful Environments

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January 31, 1991

Annual Technical Report for Period 15 December 1989 to 14 December 1990

Unclassified

Prepared for:

Air Force Office of Scientific Research /NL
Air Force Systems Command, USAF
Building 410
Bolling AFB DC 20332-6448

AFOSR/PKO
Building 410
Bolling AFB, DC 20332-6448

ABSTRACT

This grant involves three studies. The first study is designed to determine the efficacy of the catecholamine precursor L-Tyrosine in reducing pilot performance deficits caused by a night of sleep deprivation. Preparations for this study are underway and testing should begin in mid-1991. The remaining studies are designed to examine the dose-response relationships between human plasma melatonin levels and various performance and behavioral indices. Towards this end we will manipulate nocturnal melatonin levels by exposing people to varying intensities of light (Study II), daytime levels by administering exogenous melatonin (Study III). Testing for Study II should be complete and testing for Study III begun by April 1991.

A) This project involves three separate studies. The objectives of each study are as follows:

The objectives of Study I are:

1. To determine if the neurotransmitter precursor tyrosine can alleviate some of the fatigue and impaired performance that occur when simulated missions are flown by pilots after a night without sleep. We will examine changes in vigilance, reaction time and mood state that occur during the simulated mission, compare these parameters to performance on the simulator itself, and determine if any of these behaviors are facilitated by tyrosine administration.
2. To evaluate changes in auditory evoked potentials and the EEG that occur during the simulated mission and evaluate the effects of tyrosine on these parameters.
3. To study changes in various urinary catecholamines, metabolites and stress hormones during the study and determine if tyrosine administration alters these.
4. To determine if administration of tyrosine alters some of the cardiovascular consequences of stress in humans.
5. To determine if tyrosine administration has any adverse effects on the ability of pilots to fly simulated missions, or on any other behavioral or physiological variables examined. This will provide information on whether tyrosine can be used safely in similar follow-up studies.
6. To compare results from a specific battery of laboratory tests of performance and mood with concurrent performance on the flight simulator.
7. To evaluate the utility of the flight simulator paradigm combined with sleep deprivation for assessing interventions that may alleviate stress.
8. To gather performance accuracy and variability data throughout an extended mission "flown" in a realistic but controlled environment. These data will provide a base performance level for future extended mission studies and could also provide new indices of performance deterioration.

The objectives of Study II are:

1. To determine if the bright light induced suppression of the release of the hormone melatonin improves task performance and general alertness during the nadir of the circadian rhythm (sleep cycle). We will simultaneously evaluate alterations in vigilance and reaction time (visual and auditory) task performance, mood state, core temperature, and EOG that may result from the suppression of melatonin secretion.
2. To determine if effects of bright light on these behaviors is "dose" dependent. That is, if varying the intensity of the light used to suppress melatonin

release causes a corresponding change in behavior.
3. To determine how changes in plasma melatonin concentration are related to corresponding alterations in behavior.
4. To evaluate psychological, physiological, and performance changes induced by the suppression of melatonin release and thus facilitate the application of this technology to areas of direct benefit to the USAF.
5. To evaluate the usefulness of testing procedures and facilities for a future long term study of the use of light as an aid to circadian rhythm resynchronization during shifting work/sleep cycles.

The objectives of Study III are:

1. To determine if raising plasma levels of the hormone melatonin by administering exogenous melatonin decreases task performance and general alertness during the peak of the circadian rhythm (day-active cycle). We will simultaneously evaluate alterations in vigilance and reaction time (visual and auditory) task performance, and mood state that may result from increasing plasma melatonin levels beyond their normal levels.
2. To determine if effects of exogenous melatonin on these behaviors is "dose" dependent. That is, if varying the plasma melatonin level causes a corresponding change in behavior.
3. To determine how changes in plasma melatonin concentration are related to corresponding alterations in behavior.
4. To evaluate psychological, physiological, and performance changes induced by increased plasma melatonin levels and thus facilitate the application of this technology to areas of direct benefit to the USAF.

B) Work on the three studies has progressed as follows:

Study I:

1. A formal protocol has been submitted to and approved by both the MIT Committee on the Use of Humans as Experimental Subjects (COUHES) and the USAFSAM Advisory Committee on Human Experimentation (ACHE).
2. Msgt Ron Boone, is currently making repairs and modifications to the T40 flight simulator at USAFSAM to prepare the simulator for the study.
3. The hardware (80386 Computer, 2 VGA Monitors w/ controller card, Analog-to-Digital interface board) to be used for the project has been purchased and is in place at USAFSAM.
4. Mr. Jau Tsau, of USAFSAM, has completed a prototype computer program one of the 8 Flight Maneuvers Tasks and is currently modifying that computer code to the

requirements of the remaining tasks.

5. Col. Bill Ercoline (Ret., currently working for KRUG Life Sciences, San Antonio Division) has received verbal commitments from several pilots who have agreed to participate in the study.
6. Drs. French (USAFSAM) and Dollins (MIT) plan to begin testing subjects in early June of 1991.

Study II:

1. The experimental protocol for this study has been written and approved by both the MIT COUHES and the MIT Clinical Research Center (CRC) Advisory committee.
2. Dr. Wurtman has arranged to provide funds from another source to pay medical personnel necessary to complete the study (these personnel would have been provided by Dr. Storm at Brooks AFB if the study had been conducted at Brooks AFB as originally proposed).
3. Appropriate workstation furniture has been constructed and purchased and is in place, along with Four 286 AT class computers which have been modified to present auditory stimuli.
4. Appropriate light fixtures were purchased and lenses with line-patterns were constructed.
5. Dr. Dollins modified the computer code of four of the performance tasks used in an earlier AFOSR sponsored study (AFOSR-87-0402) and coded 3 additional tasks.
6. Subject testing began on Thursday, November 15, 1990. To date Drs. Lynch and Dollins have conducted 21 nights of testing and 11 subjects have completed all three test sessions. All subject testing should be completed in early March of 1991.

Study III:

1. The experimental protocol for this study has been written and approved by both the MIT COUHES and the MIT Clinical Research Center (CRC) Advisory committee.
2. The forms required to gain FDA approval for the use of melatonin with human subjects have been submitted and approved.
3. Dr. Wurtman has arranged to provide funds from another source to pay medical personnel necessary to complete the study.
4. Subject screening has begun.
5. Subject testing for this study should begin when Study II is finished in mid-march.

C) Written publications:

Dollins, A.B., Krock, L.P., Storm, W.F., & Lieberman, H.R. (1990). Tyrosine decreases physiological stress caused

by lower body negative pressure (LBNP). Aviation, Space and Environmental Medicine, 6(5) (abstract) 491.

Lieberman, H.R., Dollins, A.B., & Wurtman, R.J. (1990). Strategies to sustain and enhance performance in stressful environments (AFOSR-TR-90-0403). Bolling AFB, DC: Air Force Office of Scientific Research.

Further analyses of the work done under AFOSR-87-0402 is underway and a publication is expected later this year.

D) Professional Personnel associated with research effort:

Richard J. Wurtman, M.D.
Harry J. Lynch, Ph.D.
Andrew B. Dollins, Ph.D.
Mei Hua Deng, B.S.

E) Interactions:

i. Dr. Dollins made a presentation entitled "Tyrosine Decreases Physiological Stress Caused by Lower Body Negative Pressure (LBNP)" at the 61st Annual Scientific meeting of the Aerospace Medical Association, New Orleans, LA, May 13-17, 1990.

ii. Dr. Dollins traveled to Brooks AFB, San Antonio, TX, to meet with Drs. Storm and French and USAFSAM support personnel (Mr. Jau Tsau, Col. Bill Ercoline, Msgt. Ron Boone, Mr. Earl Fuller, Mr. Steve Stranges) on June 3, 1990 and November 5-9, 1990.